High Temperature Teaching and Test Reactor (HT^{3}R)
NRC Information Meeting

HT^{3}R Technical Information

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Outline

- Relevant licensing background information
- General description of overall HT^3R system
- Proposed reactor size, rating and operating conditions
- Passive safety features
- Use of existing technology
- Summary

HT^3R Envisioned to Function in Same Capacity as TRIGA Reactors

- TRIGA (Training, Research, Isotope production, General Atomics) has made significant contribution to current generation of nuclear power
  - Most widely used training and research reactor in the world
  - 65 reactors in 24 countries
- HT^3R & TRIGA share many characteristics:
  - Large prompt negative temperature coefficient of reactivity
  - Relatively complete retention of Fission Products
  - Immune to failure of electric power or cooling
- HT^3R is being designed to support technology development for the next generation of nuclear power

A Brief Summary of Helium-Cooled, Graphite-Moderated, Reactor Operation

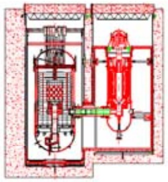
Power Reactors

Research Reactors









	Peach Bottom 1 1966-1974	Fort St Vrain 1976-1989	THTR 1986-1989	Dragon 1966-1975	AVR 1967-1988	HTTR 2000-	HTR-10 2003-
Power Level:							
MW(t)	115	842	750	20	46	30	10
MW(e)	40	330	300	-	15		--
Coolant:							
Pressure, Mpa	2.5	4.8	4	2	1.1	4	3
Inlet Temp, °C	344°C	406°C	250°C	350°C	270°C	395°C	250°C/300°C
Outlet Temp, °C	750°C	785°C	750°C	750°C	950°C	850°C/950°C	700°C/900°C
Fuel type	$(U\text{-}Th)C_2$ PyC coated particles	$(U\text{-}Th)C_2$ TRISO	$(U\text{-}Th)O_2$ TRISO	$(U\text{-}Th)C_2$ PyC particles	$(U\text{-}Th)O_2$ TRISO	$(U\text{-}Th)C_2$ PyC particles	$(U\text{-}Th)O_2$ PyC particles
Peak fuel temp, °C	~1000°C	1260°C	1350°C	~1000°C	1350°C	~1250°C	
Fuel form	Graphite compacts in hollow rods	Graphite Compacts in Hex blocks	Graphite Pebbles	Graphite Hex blocks	Graphite Pebbles	Graphite compacts in Hex blocks	Graphite Pebbles

*** More than 30 CO2-cooled, graphite-moderated reactors have been built and 10 are nowoperating in the United Kingdom for power production.*

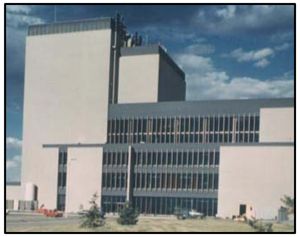
TRISO particles are fuel kernels coated with SiC and PyC

RENEWED WORLD-WIDE INTEREST IN HELIUM-COOLED REACTORS BECAUSE OF THEIR SAFETY AND HIGH TEMPERATURE APPLICATIONS

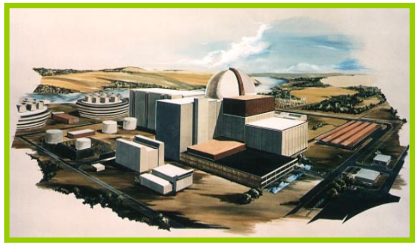
Significant Experience Exists for High Temperature Gas Reactor (HTGR) Licensing

- **Peach Bottom 1 ('67 - '74)**
  - Construction License
  - Operating License
  - Decommissioned

- **Fort St Vrain ('79 - '88)**
  - Construction License
  - Operating License
  - Decommissioned



- **Large HTGR (mid '70s)**
  - Summit 1 & 2 construction permit issued
  - Fulton 1 & 2 PSAR submitted

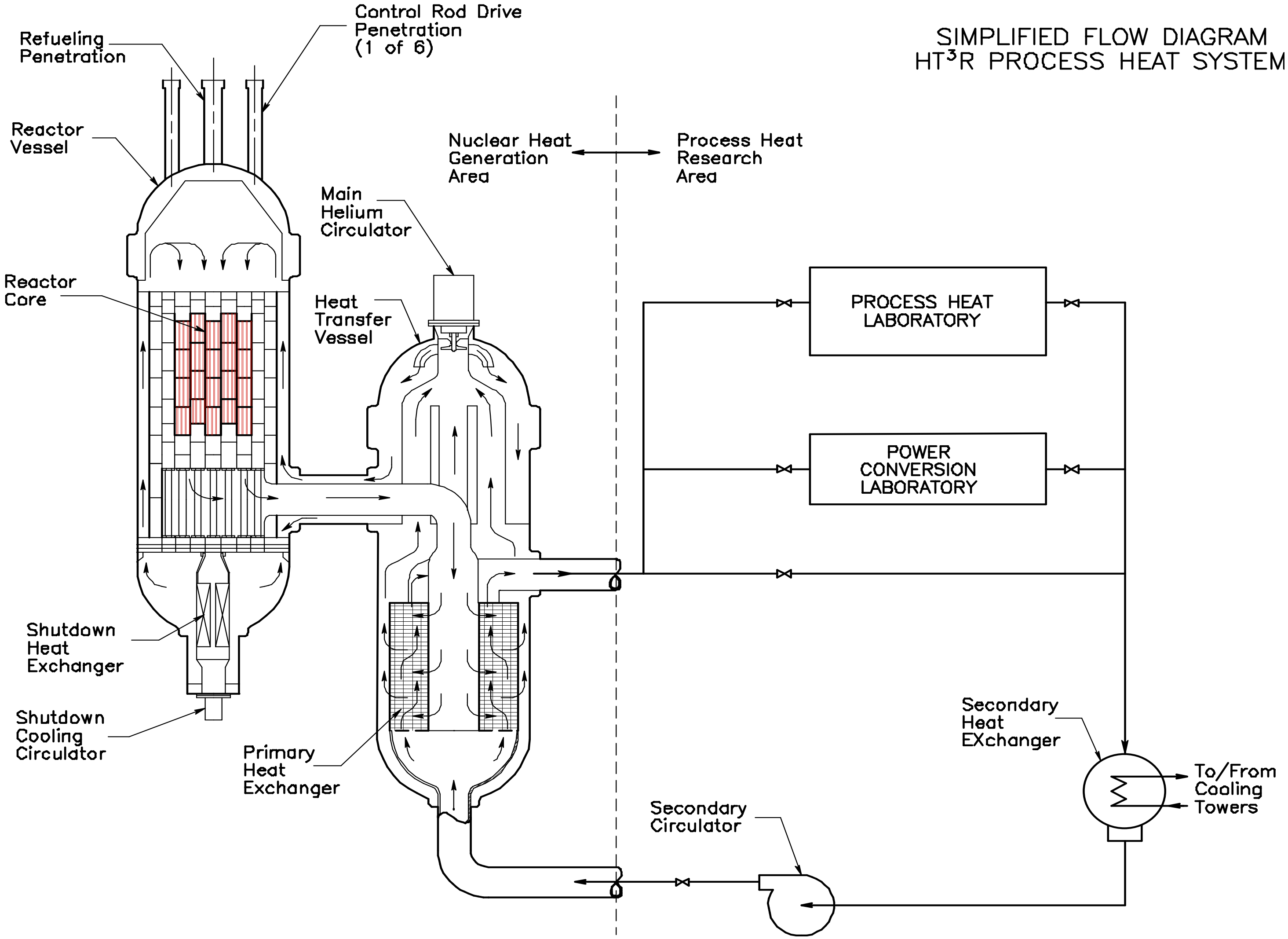


- **Modular HTGR (late '80s)**
  - Preliminary Safety Information Document (PSID) submitted to and reviewed by NRC

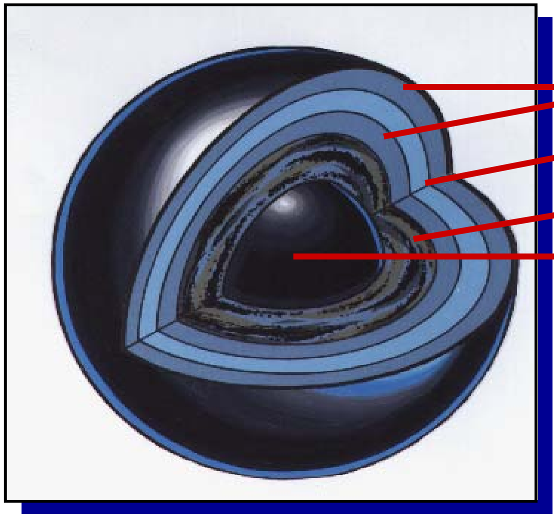
Overall System Characteristics Selected for HT^3R

- HTGR key characteristics (Helium coolant, graphite moderator, coated particle fuel)
- Proven hexagonal graphite fuel element blocks with coated particle fuel in compacts; 10% enriched UO_2 fuel
- Passive safety characteristics same as modular helium reactors
- Coolant circulator and heat exchanger in primary loop. (Reactor heat transfer through heat exchanger to secondary loop for rejection to atmosphere)
- Provisions for add-on heat utilization systems in secondary loop

Schematic HT³R Process Flow Diagram



Coated Particle Fuel Ceramic Coatings Retain Their Integrity Under High Temperature Conditions



Pyrolytic Carbon

Silicon Carbide

Porous Carbon Buffer

Fuel kernel (LEU)

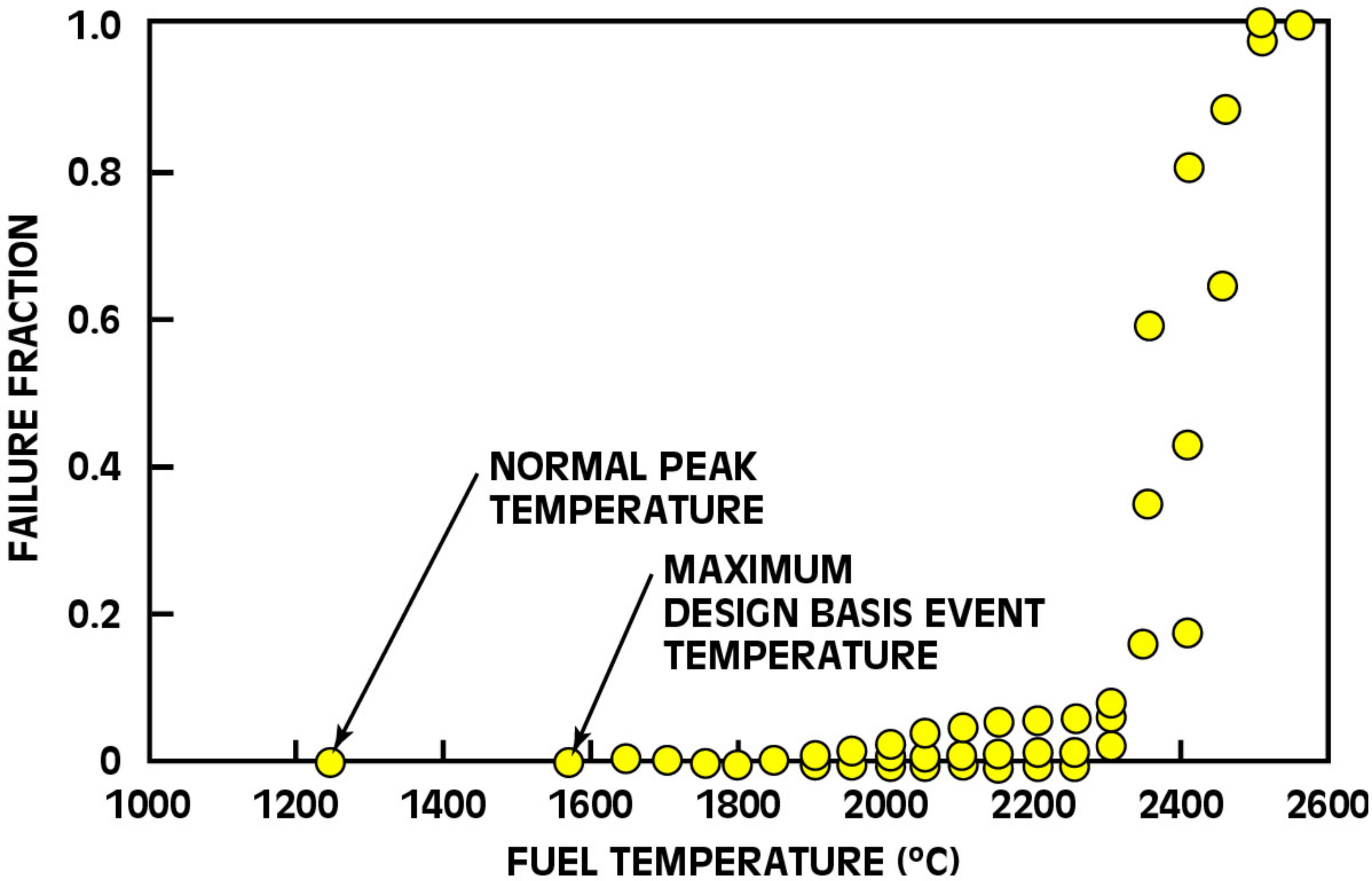
TRISO Coated fuel particles (left) are formed into fuel rods (center) and inserted into graphite fuel elements (right).

PARTICLES

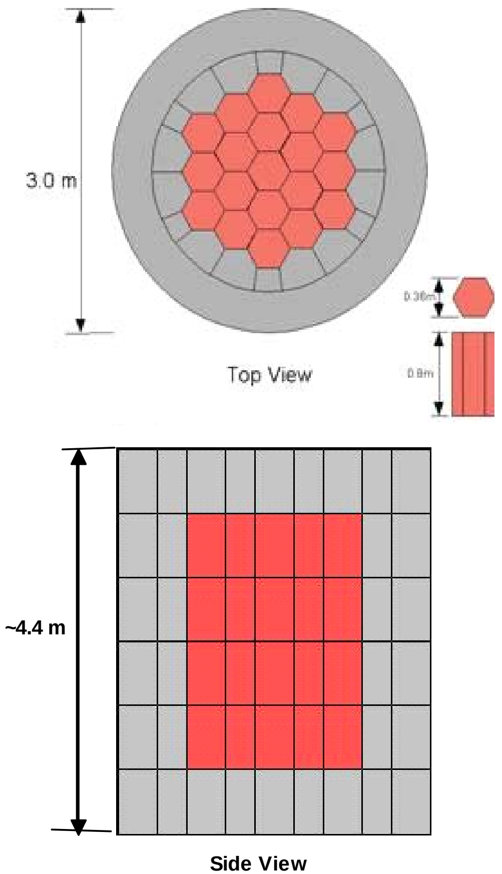
COMPACTS

FUEL ELEMENTS

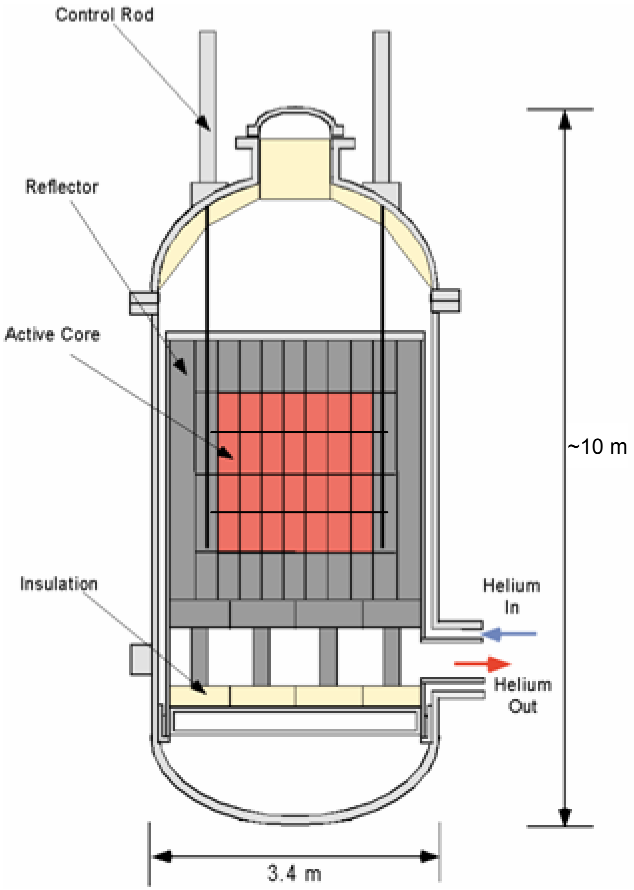
Coated Particles Stable To Beyond Maximum Accident Temperatures



General Arrangement of HT³R Reactor System



HT³R Core Arrangement

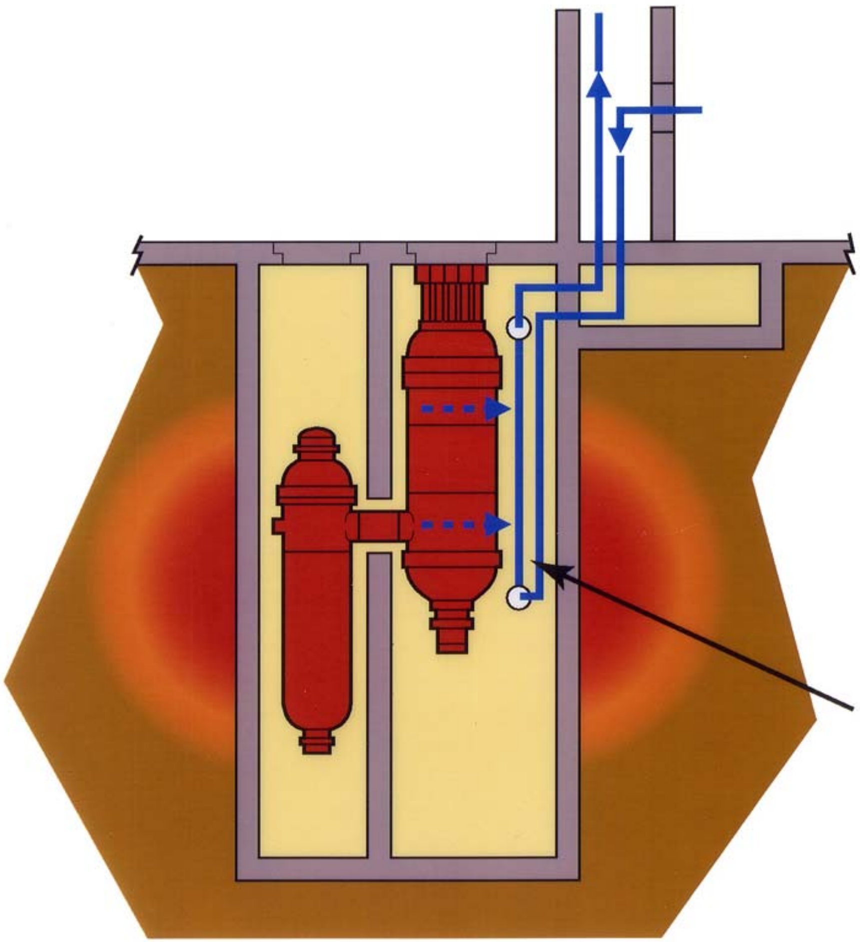


HT³R Reactor Arrangement

Proposed HT^3R Core Size, Rating and Operating Conditions

- **Tentative core selection:**
  - Hexagonal fuel element block 360 mm wide (across flats) by 793 mm high
  - 76 fuel element blocks, 19 columns, 4 rows high
  - 25 MWt power
- **Key selection criteria include:**
  - Thermal power level sufficient for generating 10 MWe *(with suitable power conversion system)*
  - Fuel performance within proven limits
- **Key operating parameters include:**
  - Outlet temperature ~850°
  - Power density ~3.5 w/cc
  - Max fuel temp <1250°C
  - Primary system pressure ~3MPa

HT³R Design to Include Passive Reactor Cavity Cooling System for Removal of Core Decay Heat



- Primary system located below grade in concrete silo
- Decay heat radiates from vessel to natural draft air cooling system
- No pumps or fans required

HT^{3}R Passive Safety by Design

- **Fission Products Retained in Coated Particles**
  - High temperature stability materials
  - Refractory coated fuel
  - Graphite moderator
- **Worst case fuel temperature limited by design features**
  - Low power density
  - Passive heat removal
- **Core Shuts Down Without Rod Motion**

HT^{3}R Being Designed to Use Existing Technology

- **Design objective: Use of proven technology to maximum possible extent (little or no need for new R&D)**
- **Design approaches and principles:**
  - Use of proven fuel element and fuel particle designs
  - Fuel designed to operate within proven performance parameters
  - Use of materials qualified for the intended service conditions
  - Use of previously proven service and auxiliary systems
  - Design characteristics having test reactor licensing precedence

Summary of HT^{3}R Technical Information

- Licensing to draw upon prior TRIGA and gas reactor licensing experience
- Employs key HTGR characteristics (He coolant, graphite moderator, coated particle fuel)
- Tentative core size, rating and operating conditions identified
- Passive safety capability
- Use of existing technology to maximum practical extent